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Incidence of Western Spruce Budworm Parasites in New Mexico after Aerial Spraying with Carbaryl

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Percent parasitism by *Glypta fumiferanae* Viereck decreased significantly in the sprayed areas following application, while *Phytodietus fumiferanae* Rohwer parasitism increased in the same areas. *Apanteles fumiferanae* Viereck increased significantly in two of the sprayed areas the first year after spraying, but percent parasitism generally followed similar patterns in treated and untreated areas. *Ceromasia auricaudata* Townsend decreased significantly in the sprayed areas the first year after spraying, but 2 years after spraying percent parasitism by this species was about equal in both sprayed and unsprayed areas. Other insect parasites exhibited similar trends in sprayed and unsprayed areas during the 2 years following spraying, or their numbers were too meagre to determine a trend.

Keywords: Western spruce budworm, *Choristoneura occidentalis,* insect parasites.

Management Implications

Because the incidence of parasitism for nearly all parasites was not adversely affected by carbaryl spraying, forest managers can use the insecticide without fear of eliminating the parasites.

The parasitic insects associated with the spruce budworms *Choristoneura occidentalis* Freeman and *C. fumiferana* (Clemens) in North America are well known, and their relative abundance has been documented for several geographically distinct areas. Also known, but less well documented, is the effect of insecticides on the incidence of parasitism by these parasites. Several studies (Macdonald 1959, Williams et al. 1969, McGregor 1970,[2] Leonard and Simmons 1974) have noted trends in the incidence of parasitism following the application of insecticides against the host. Such studies have become increasingly important because forest managers feared the insecticide would eliminate the parasites and release the host from their effect, thereby allowing the host population to rapidly attain damaging status again. The study reported herein investigated the effect of carbaryl,[3] applied at the rate of 1.1 kg per hectare, on the incidence of parasitism of western spruce budworm, *C. occidentalis,* larvae in northern New Mexico.

Methods

Study Area

The Forest Pest Management Staff, USDA Forest Service, Southwestern Region, divided the infested host area on the Santa Fe National Forest in Sandoval, Rio Arriba,

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[2] *McGregor, M. D. 1970. Evaluation of the incidence of western budworm,* Choristoneura occidentalis, *parasitism 1 year after the application of Zectran insecticide. Unpublished Report, 4 p. USDA Forest Service, State and Private Forestry, Intermountain Region, Missoula, Mont.*

[3] *The use of trade and company names is for the benefit of the reader; such use does not constitute an official endorsement or approval of any service or product by the USDA to the exclusion of others that may be suitable.*

and Los Alamos counties, New Mexico, into 12 areas for sampling purposes. The areas ranged in size from ca. 1,700 to 4,400 ha. Six areas in the Nacimiento Mountains were sprayed with carbaryl during June 10-17, 1977, while two additional areas in the Nacimiento Mountains and four areas in the Jemez Mountains to the east were left untreated to serve as controls. Areas 1-6 were sprayed and 7-12 were unsprayed. At the time of treatment, larval counts of 14.9 per 100 buds in the sprayed area were not significantly different from the 12.4 per 100 buds in the unsprayed area (Parker et al. 1978). In 1978, one year after spraying, larval densities were 0.9 per 100 buds in the sprayed area and 8.7 per 100 buds in the unsprayed area (Parker et al. 1979). In 1979, 2 years after spraying, the mean larval density for the untreated areas of 9.0 per 100 buds was significantly greater than the density of 0.6 per 100 buds (table 1) for the treated areas (Parker and Ragenovich 1980).

Larval Collections and Analysis

Larvae in stages 3-5 and 5-6 were collected from one arbitrarily selected location in each area. Two separate collections were made because different parasites are present in the earlier instars than in later instars. Larvae in stages 3-5 were collected June 10-13, 1977; June 6-7, 12-14, 1978; and June 12-19, 1979. Larvae in stages 5-6 were collected June 28-29, 1977; June 20, 24-27, 1978; and June 26-July 1, 1979. Because larval development on the west side of the project area (areas 1-6) lagged behind larval development on the east side, collections were first made on the east side and then on the west side to provide more uniformity in the developmental stages and thus comparability between the sprayed and unsprayed areas. Collections during June 10-13, 1977 were scheduled just prior to the carbaryl application in each area.

The goal for each collection from each area was 200 larvae. However, the scarcity of larvae after spraying prevented collection of this number in the sprayed areas, so a crew of workers collected only as many larvae as they could in 3-4 hours. Collections totaled only 35-90 larvae for areas 2 and 5.

Larvae were handpicked from branches in the lower crowns of Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, and white fir, *Abies concolor* (Gord. and Glend.) Lindl., as well as from mid-crown branches cut from the trees with a pole pruner. Larvae were collected from the lower and middle crowns because it was more efficient, especially after spraying. Because significant differences in percent parasitism between crown levels existed for only *Meteorus trachynotus* Viereck (Hymenoptera:Braconidae),[4] larvae from lower and middle crown branches were pooled together without significantly changing the percent parasitism. A maximum of 15 larvae was collected from a single tree, so that at least 14 trees were sampled to obtain the 200 larvae. Generally more than 50 trees were examined for larvae in sprayed areas where larval numbers became so reduced that the majority of the trees bore no larvae. Because larvae were scarce, collecting with a pole pruner and basket became inefficient and was used sparingly in the sprayed areas.

Larvae were collected mainly from Douglas-fir in the initial 1977 samples. After spraying, larvae were easier to find on white fir in the sprayed areas, so they were collected thereafter mostly from white fir in the treated and untreated areas. Differences in percent parasitism between host species were not recognized until later but, because larvae were collected from the two hosts in the same proportions in the treated and untreated areas, the influence of host differences was probably negligible. It is discussed for those species where it may have had an effect.

The collected larvae were placed in petri dishes with foliage or artificial diet and transported to Fort Collins where they were reared in the laboratory until the adults or parasites emerged. Because some larvae died during handling and transportation, the number of emerging moths and parasites was less than the number of larvae collected in the field.

When most of the moths had emerged, the dishes were examined and the parasites determined. Each parasite was identified to species, if possible. The percent parasitism by each species was then determined and was based on the number of parasites and budworms that emerged—not on the number of collected larvae. Percent parasitism for each species was then tested in an analysis of variance for significant variation associated with treatments and years, P=0.05. When significant variation was present between years, Tukey's test was used to determine the relationship between years.

Table 1.—Western spruce budworm larvae and pupae per 100 buds (from Parker and Ragenovich 1980)

	1977	1978	1979
Treated areas			
1	20.5	1.3	0.3
2	11.9	0.4	0.5
3	11.7	0.4	1.0
4	17.9	1.2	0.7
5	18.2	1.5	0.1
6	9.0	0.6	0.9
Mean	14.9	0.9	0.6
Untreated areas			
7	2.7	2.0	1.4
8	9.5	10.7	11.8
9	8.7	11.8	11.2
10	17.7	11.5	10.6
11	12.6	10.8	9.2
12	14.3	5.5	9.7
Mean	12.4	8.7	9.0

Results and Discussion

Five species of braconids, 17 ichneumonids, and 9 tachinids were reared from the budworms during the 3 years (table 2). Their abundance varied from year to year and between collection sites. The percent parasitism for most species averaged less than 1% each year for the 12

[4] *Schmid, John M. Unpublished data on file at the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.*

Table 2.—Average percent parasitism for parasites and hyperparasites reared from western spruce budworms from 12 locations on the Santa Fe National Forest in northern New Mexico

	Percent paracitism [1]
Hymenoptera	
Braconidae:	
Microgasterinae	
Apanteles fumiferanae Viereck	5-15, >15
Apanteles milleri Mason	<1
Apanteles absonus Musebeck	<1
Euphorinae	
Meteorus trachynotus Viereck	<1, 1-5
Agathidinae	
Agathis acrobasidis (Cushman)	<1
Ichneumonidae:	
Ephialtinae	
Scambus sp. near *aplopappi* (Ashmead)	<1
Itoplectis conquistor Say	<1
Itoplectis quadricingulata (Provancher)	<1
Itoplectis vesca Townes	<1
Ephialtes ontario (Cresson)	<1
Tryphoninae	
Phytodietus fumiferanae Rohwer	<1, 1-5, 5-15
Banchinae	
Glypta fumiferanae Viereck	5-15
Porizontinae	
Sinophorus sp.	<1
Campoplex sp.	<1
Cremastinae	
Psristomerus baumhoferi Cushman	<1
Temelucha evetriae Cushman	<1
Mesochorinae	
Mesochorus vittator Zetterstedt	<1
Stictopisthus flaviceps Provancher	<1
Metopinae	
Exochus nigripalpis Thompson	<1
Exochus n. sp.	<1
Anomalinae	
Habronyx near *aclerivorus* Rohwer	<1
Ichneumoninae	
Phaeogenes maculicornis hariolus (Cresson)	<1
Diptera	
Tachinidae:	
Madremyia saundersii (Williston)	1-5, 5-15
Timavia fumiferanae (Tothill) — formerly Omotoma	<1
Aplomya caesar (Aldrich)	<1
Phryxe pecosenis (Townsend)	<1, 1-5
Erynnia tortricis (Coquillett)	<1
Xanthophyto labis (Coquillett)	<1
Nemorilla pyste (Walker)	<1
"Phorocera" nr. *festinans* Aldrich and Webber (Generic position of *Phorocera* uncertain)	<1
Ceromasia auricaudata Townsend	<1, 1-5, 5-15

[1] *Four categories of abundance are recognized: <1, 1-5, 5.1-15, and >15% of the hosts parasitized. Three of the categories are redefined from Dowden et al. (1948). More than 1 value indicates the average percent parasitism was not constant each year and varied during the 3 years.*

locations. A few species increased or decreased from year to year, so their average percent parasitism varied during the 3 years. Because percent parasitism varied from year to year at specific locations, the average rate was quite different from the percent parasitism for a particular locality.

Mean percent parasitism for two ichneumonid parasites showed significant but opposite changes after spraying. *Glypta fumiferanae* Viereck in the sprayed areas decreased significantly by the second year, while percent parasitism in the unsprayed areas changed insignificantly during the second year (table 3). Percent parasitism by *Phytodietus fumiferanae* Rohwer increased slightly the first year after spraying and significantly the second year, while percent parasitism in the unsprayed area remained about the same (table 4). The significant increase in parasitism by *Phytodietus* in the sprayed area (table 4) has not been

Table 3.—Percent parasitism of stage 3-5 budworm by species

Area	*Apanteles fumiferanae* 1977	1978	1979	*Glypta fumiferanae* 1977	1978	1979	*Apanteles milleri* 1977	1978	1979	*Phytodietus fumiferanae* 1977	1978	1979
Treated												
1	12	1	8	11	2	1	0	0	0	0	3	6
2	23	47	22	8	2	0	0	0	1	0	1	1
3	23	20	3	11	2	0	0	0	0	2	2	1
4	15	20	3	5	4	0	0	0	0	0	2	5
5	11	51	26	4	3	0	4	0	0	0	0	0
6	23	24	5	12	1	<1	2	0	0	0	2	7
Mean	18	27	11	8	2	<1	1	0	<1	<1	2	3
Untreated												
7	11	4	5	3	4	2	0	0	0	0	11	2
8	12	8	10	24	16	16	0	0	<1	0	0	0
9	15	11	17	21	20	11	<1	0	0	0	1	0
10	34	6	16	22	15	9	0	0	<1	0	1	0
11	21	8	12	4	13	8	0	0	0	0	0	0
12	22	10	21	10	25	9	0	0	0	0	2	0
Mean	19	8	13	14	16	9	<1	0	<1	0	2	<1

Table 4.—Percent parasitism of stage 5-6 budworm by species

Area	*Apanteles fumiferanae* 1977	1978	1979	*Glypta fumiferanae* 1977	1978	1979	*Phytodietus fumiferanae* 1977	1978	1979	*Mesochorus vittator* 1977	1978	1979	*Geromasia auricaudata* 1977	1978	1979
Treated areas															
1	0	0	4	6	2	1	<1	2	12	0	0	0	23	0	0
2	0	<1	6	3	3	0	0	5	25	0	0	0	11	3	0
3	1	0	2	3	2	2	1	0	5	0	0	0	20	9	1
4	0	0	0	3	3	1	0	2	17	0	0	0	29	3	1
5	1	11	13	4	4	0	0	<1	29	0	<1	0	25	0	0
6	1	<1	<1	6	3	<1	0	1	25	0	<1	0	2	2	0
Mean	<1	2	4	4	3	<1	<1	2	19	0	<1	0	18	2	<1
Untreated areas															
7	0	1	<1	3	4	1	3	2	5	0	<1	1	0	0	<1
8	1	2	2	29	20	22	0	1	0	0	<1	0	8	11	0
9	6	6	3	16	24	11	0	<1	0	0	<1	1	7	4	1
10	5	3	2	12	18	9	0	3	1	0	0	0	10	7	<1
11	5	2	2	14	26	15	0	0	0	0	<1	0	5	3	1
12	3	3	4	14	12	19	0	3	1	0	0	1	6	4	1
Mean	3	3	2	15	17	13	<1	2	1	0	<1	<1	6	5	<1

Area	*Madremyia saundersii* 1977	1978	1979	*Timavia fumiferanae* 1977	1978	1979	*Phryxe pecosensis* 1977	1978	1979	*Phaeogenes maculicornis* 1977	1978	1979	*Meteorus trachynotus* 1977	1978	1979
Treated areas															
1	2	5	1	0	0	0	<1	0	0	0	2	0	0	2	0
2	6	2	1	0	0	0	5	0	0	0	<1	0	0	1	0
3	7	8	2	<1	<1	1	2	1	0	0	0	0	<1	2	0
4	3	3	1	0	0	0	1	0	0	<1	1	0	0	<1	0
5	6	3	0	0	0	0	2	0	0	0	0	0	8	12	0
6	1	17	3	0	0	1	2	0	0	0	2	0	<1	1	0
Mean	4	6	1	<1	<1	<1	2	<1	0	<1	<1	0	1	3	0
Untreated areas															
7	0	0	0	0	0	<1	0	0	0	0	<1	<1	0	1	0
8	<1	6	0	0	0	0	1	1	0	0	0	0	0	0	0
9	2	6	6	0	<1	4	1	0	0	1	1	0	<1	5	0
10	3	6	4	0	0	2	2	<1	1	0	0	0	1	2	0
11	3	9	4	0	0	2	<1	0	0	1	0	<1	1	0	0
12	3	5	1	0	<1	1	0	1	0	2	<1	0	<1	<1	0
Mean	2	5	2	0	<1	2	<1	<1	<1	<1	<1	<1	<1	1	0

documented in previous studies, probably because of its limited abundance.

Results for *Glypta* agree with similar changes observed by Macdonald (1959). Macdonald also notes that this species exhibited a continuing decline in abundance over the course of the outbreak, suggesting lesser importance for it as an outbreak progresses. The apparent decrease in parasitism in the unsprayed area during the second year may be further evidence for this type of trend.

One braconid, *Apanteles fumiferanae* Viereck, increased markedly in two of the six sprayed areas (table 3) the first year after spraying, but the mean percent parasitism for all areas combined indicates an insignificant increase. Simultaneously, parasitism by this species in all the unsprayed areas decreased, so the mean percent parasitism for the unsprayed area was significantly less than that of the sprayed areas. During the second year after spraying, parasitism decreased in five of the six sprayed areas while parasitism was increasing in the unsprayed area, so that mean percent parasitism for the sprayed and unsprayed areas was insignificantly different. Previous authors (Macdonald 1959, Williams et al. 1969, Leonard and Simmons 1974, Hamel 1977) have noted greater percent parasitism by *A. fumiferanae* in sprayed areas the first year after spraying, but their differences were either not significant, estionable, or imprecisely related to the insecticide apıcation. The general trend here is insignificant changes .e two post-spray years for all sprayed areas, except for ıe collection sites in areas 2 and 5 where large changes occurred the first and second years respectively.

Parasitism increased greatly the first year after spraying in the collection locations in areas 2 and 5 where the larvae were extremely scarce in the 2 years following spraying. Macdonald (1959) suggests that *Apanteles* may survive spray programs because they emerge from the host and spin cocoons before spraying, and because the moribund host is less likely to contact the residual insecticide. Thus, the high rates of parasitism in areas 2 and 5 could be explained by Macdonald's reasoning. However, the other four sprayed areas subject to the same conditions exhibited insignificant changes, so that further explanation is required. Budworm populations may have to be drastically reduced before *Apanteles* parasitism would significantly increase in later years. If budworm populations are reduced one year and *Apanteles* populations are unaffected the same year, this would create a high ratio of parasite to prey in the next generation and increase the probability of greater percent parasitism in the budworm generation.

Parasitism by the tachinid *Ceromasia auricaudata* Townsend decreased significantly in the sprayed area the first year following spraying (table 4),so that parasitism in the spray and check areas was not significantly different. Simultaneously, parasitism by this species in the unsprayed area did not decline significantly until the second year. The percent parasitism was the same in both sprayed and unsprayed areas in 1979. The trend of this tachinid agrees with the results of Leonard and Simmons (1974) although they lumped all tachinid species into one group. Because *C. auricaudata* was insignificantly more abundant on Douglas-fir than on white fir,[4] collecting more from the white fir after the spraying may have slightly influenced the trend, but was believed to be insignificant because white fir was sampled in the same proportions in the sprayed and unsprayed areas.

The percent parasitism of the other parasites and hyperparasites either exhibited similar trends in both the sprayed and unsprayed areas during the 2 years following spraying or their numbers in each area were too meagre to determine a trend. Trends for the tachinids may have been more noticeable if pupal collections had been made. The braconid, *Meteorus trachynotus* Viereck, was more abundant in the upper levels of the crown,[4] so that sampling of the lower and middle crowns may not have adequately relected its trend. The ichneumonid *Mesochorus vittator* Zetterstedt is a hyper-parasite of *A. fumiferanae*. Percent parasitisms for this species are misleading since the ichneumonid is indirectly responsible for the numbers of budworm destroyed. However, they are retained because they indicate the general abundance of this species.

Conclusions

Percent parasitism by the insect parasites following spraying showed a few increases and decreases but most were not significantly affected. The results agree with Macdonald's 1959 general statement that the parasites were not in danger of elimination by the spray program.

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Pesticide Precautionary Statement

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some states have restrictions on the use of certain pesticides. Check your state and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or state extension specialist to be sure the intended use is still registered.

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